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Provocative discography and minimally invasive procedures for the treatment of discogenic pain

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Abstract

Diagnosis and treatment of lumbar discogenic pain remains a challenge. It may account for 1/3 of patients with lower back pain. The mechanism of discogenic pain remains unclear, clinical presentation can vary and the MRI may only suggest the presence of internal disc disruption. Provocative discography can provide unique information about the morphology of the disc and remains the only diagnostic test that can relate the changes observed on imaging tests and the patient's pain. Minimally invasive treatments like intradiscal biacuplasty or intradiscal electrothermal therapy are likely better alternatives to the currently available surgical options. They are cost effective and may cause fewer side effects. However, the value of most of these therapies has yet to be established. More basic science and clinical studies are needed to prove the clinical efficacy of such minimal invasive treatments. One thing that is clear, however, is that the careful patient selection, based on the present data, significantly improves successes of these procedures.

INTRODUCTION

Despite its high incidence, the diagnosis of discogenic pain often remains imprecise secondary to its non-specific clinical features. Typical features include persistent, nociceptive low back, groin and/or leg pain that worsens with axial loading and improves with recumbency. These features alone, however, are frequently insufficient to establish an accurate diagnosis and comprehensive treatment plan for patients with such complaints. This has led many practitioners to employ provocative discography in conjunction with magnetic resonance imaging (MRI) studies as a means of validating their clinical diagnosis of discogenic pain. Although MRI images are helpful in visualizing such pathology as disk degeneration and desiccation, high-intensity zones and loss of disk eight, the results commonly correlate poorly with clinical findings, leaving open the critical question of causality. To date, provocative discography is the only available method of linking the anatomic abnormalities seen on MRI with clinically observed pain *(1–12)*.

Provocative discography

Arguably the most reliable tool currently available for the diagnosis of discogenic pain is the technique of discography. It elucidates the architecture of suspected symptomatic intervertebral discs, and can often confirm the clinical suspicion of a discogenic pain. The first discography results were published by Lindblom in 1948 *(1–3)*, and the diagnostic procedure became popular in 1960's *(4–6)*. This was followed

by a series of discography studies, further supporting the diagnostic value and validity of the procedure *(7)*. The validity and reliability of these claims, however, has often since been questioned *(8–12)*. If performed by experienced dicographers, using modern methods and in psychologically normal patients, the false positive rate of lumbar discography remains low *(11–12)*. Discography presently remains the most reliable tool to directly relate a radiographic image to the patient's pain *(12–15)*.

Specific indications for discography include: Assessment of patients in whom surgery has failed, to determine whether pseudoarthrosis or a symptomatic disk in a posteriorly viewed segment could be the source of pain; Assessment of disks prior to fusion to determine whether the disks of the proposed fusion segment are symptomatic and whether the disks adjacent to this segment can support a fusion; Persistent, severe symptoms when other diagnostic tests have failed to clearly confirm a suspected disk as a source of the pain; Evaluation of abnormal disks or recurrent pain from a previously operated disk or lateral disk herniation; Assessment of candidates for minimally invasive surgery who have a confirmed disk herniation.

From a technical standpoint, discography requires introduction of a needle into the center of the disc under the guidance of fluoroscopy with injection of contrast into the disc (Figure 1, 2). The volume of contrast injected, opening and peak pressures, as well as the patient's responses including pain location, severity and quality are documented. In terms of location, quality and severity, if the patient experiences similar pain as their baseline pain, it is termed »concordant« pain. »Non-concordant« pain means the pain is dissimilar from the baseline symptoms.

Discography is thought to provoke pain by the following mechanisms: The injection may increase pressure at the end plates, or pressure may be transferred to the vertebral body throughout the end plate, resulting in an increase in intravertebral pressure *(15–19)*. This theory is supported by studies reporting disk injection resulting in end-plate deflection and increased specimen height *(17, 18)*. The injection may result in some biochemical or neurochemical stimulation that causes pain. The presence of pain on injection of a seemingly normal disk may be due to transfer of pressure from the injection to an abnormal, symptomatic adjacent disk, thus eliciting a positive pain response *(18)*. The injection of contrast material into the disk may increase intradiscal pressure. In an abnormal disk, stretching of the annular fibers of the disk may stimulate nerve endings *(16)*.

During the discography, the disc morphology, i.e., disc height, location of annular tear and any contrast leakage are documented. In the last decade, investigators have also begun to study opening pressure of the disc, pressure at onset of pain, peak pressure and plateau pressure *(12)*. According to Derby *(12),* the pressure at which the pain is experienced, may be used to divide discs into four different pathologic categories: 1) Normal disc has no pain; 2) Chemically sensitive discs have pain at a pressure less than 15 psi above opening pressure; 3) Mechanically sensitive discs have pain provoked at pressure between 15 and 50 psi above the opening pressure; 4) Indeterminate discs experience pain between 51 and 90 psi above opening pressure.

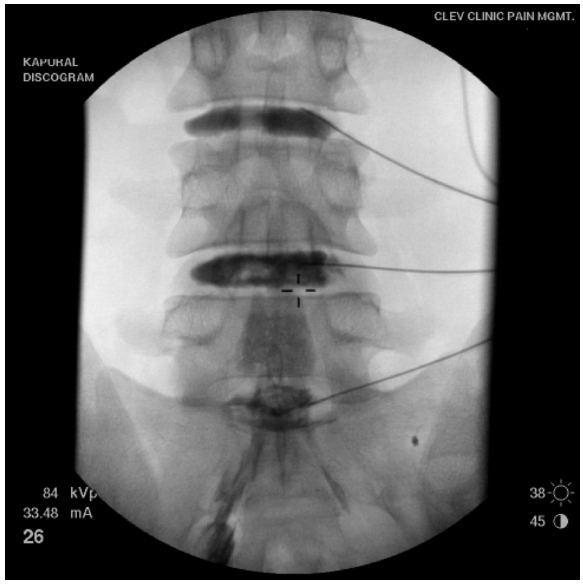

Figure 1. *Anterior-posterior view of contrast distribution during the lumbar provocative discography. Note the rounded shape of the L3–4 and L4–5 intradiscal contrast spread, while it appears a significant contrast leak from the L5–S1 intervertebral disc.*

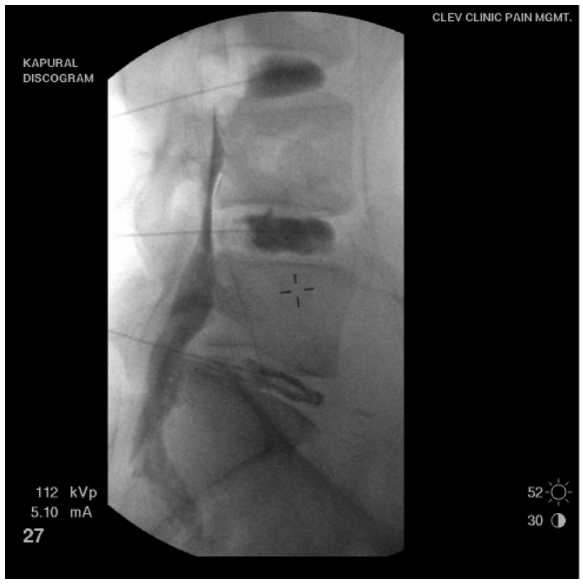

Figure 2. *Lateral fluoroscopic view of the intradiscal contrast spread during provocative discography. L3–4 and L4–5 discs were non-painful controls and L5–S1 had an obvious large contrast leak into the epidural space. Patient reported pain of 8 with pressurization of that particular disc at only 22 psi.*

Importantly, one or two asymptomatic discs with normal morphology should be evaluated by discography and

used as a control to increase the reliability of data.Internal disc disruption can be graded in five levels according to the modified Dallas Classification: 1) Grade 0 = normal disc; 2) Grade 1 = contrast spreads radially, fissure extends to the inner third of the annulus fibrosus; 3) Grade 2 = contrast extends to the middle third of the annulus fibrosus; 4) Grade 3 = contrast extends into the outer third of the annulus fibrosus, to an extent of less than 30 degrees of disc circumference; 5) Grade 4 = a grade 3 tear that dissects the outer third of annulus fibrosus for more than 30 degrees; 6) Grade 5 = A tear involving the full thickness of the annulus with extra-annular leakage *(14)*.

Since its conception, the clinical value of discography has been the focus of ongoing debate. The majority of recent studies, however, appear to strongly favor the use of discography for clinical diagnosis and guidance for therapeutic decision-making *(12, 20 –25)*.

The results of laser disc decompression (LDD) for lumbar disc herniation were evaluated by Ohnmeiss *et al. (20)*. One-year success rate of LDD for the patients with contained disc herniation confirmed by CT discography was 70.7%, while success rate for those without CT discography confirmation or with extravasation of contrast was only 44%. A well-defined collection of contrast in a protruded or herniated disc with positive pain provocation has been reported as a good predicator for success of chemonucleolysis *(26, 27)*. These studies demonstrate the importance of pain reproduction during discography for predicting procedure success.

The utility of discography for spine fusion has also been studied by Colhoun *et al. (28),* who found that patients with both positive discographic image and pain provocation had an 88% rate of surgical success. This represented a significant difference from the group with a positive image but no symptomatic pain reproduction, in which the success rate was only 52%.

Derby *et al. (12)* reported that pressure-controlled discography could predict outcome of different surgical techniques. In this study, 96 patients with discogenic pain confirmed by CT discography were randomized to undergo interbody fusion, combined fusion, intertransverse fusion or no surgery. The patients with low intradiscal pressure responsive (chemical) discs achieved significantly better long-term results with interbody and combined fusions than with intertransverse fusion. These results illustrate that precise categorization of positive discographic findings may greatly facilitate therapeutic decision-making.

Regarding complications of discography, there exist five reported cases of acute lumbar disk herniation precipitated by discography. New-onset or a persistent exacerbation of radicular symptoms may also emerge following provocative discography, meriting further investigation. Discitis has an incidence of approximately 2–3% when a single-needle technique is used. A double-needle approach reduces this risk to 0.7%, likely less when prophylactic antibiotics are used *(1–19)*.

Annuloplasty

Once the diagnosis of discogenic pain has been suitably established, the next challenge involves instituting an effective therapy. Several of the most common current therapies involve careful heating of the annulus fibrosus. Historically, these modalities have been used despite a somewhat poorly understood relationship between the therapeutic effects and the histologic changes observed *(29–33)*. It is presently held that denervation of the tissue or destruction of the nociceptors, as well as alteration of the collagen fibers in the annulus producing denaturation and coalescence is the predominant mechanism of effect *(30–33)*. Major advantages of these procedures generally include their minimally invasive approach, low cost, and relative simplicity versus surgical procedures such as lumbar fusion or disk replacement. Intradiscal Electrothermal Therapy (IDET; Smith and Nephews, London, UK), DiscTrode (Radionics Inc., Burlington, MA) and Intradiscal Biacuplasty (Baylis Medical Inc., Montreal, Canada) (Figure 1b–d) are several examples of approaches using heat to treat discogenic pain.

When considering indications for interventional approaches such as IDET annuloplasty, the most common criteria include discogenic low back pain, persistently present for more than 6 months. Further, this pain must remain despite comprehensive conservative treatment including physical therapy, a directed exercise program and at least one fluoroscopically guided epidural corticosteroid injection. Saal and Saal initially prescribed additional criteria for IDET that included: normal neurological examination, negative straight leg raise, absence of any inflammatory arthritides or nonspinal conditions that may mimic lumbar pain, and absence of prior surgery at the symptomatic intervertebral disk level *(34–36)*. Further, no neural compressive lesions should be seen on MRI, and provocative discography should reproduce concordant pain at low pressurization at one or more – but no more than three – intervertebral disk levels. This criteria set was one of several variations used in subsequent studies evaluating the efficacy of IDET *(37)*. When comparing the studies, variation in patient selection, as well as heating techniques, are thought to account for differences seen in clinical results *(37–46)*.

Overall, the average pain score improvement in 13 studies analyzed were between 1.5 to 5 VAS points. SF-36 physical function (PF) scores for evaluation of functional capacity improved from approximately 15 to 30 in four separate studies *(37)*. Overall results of IDET appear to improve with several additional patient-selection criteria *(40, 46)*. Such criteria are evaluated in Pauza and colleagues' sham-controlled, prospective IDET study. Specifically, they restricted patients to: 1. Beck depression scale score of <20; 2. Less than 20% disk height narrowing on lateral X-Ray; 3. No surgical interventions within previous 3 months of study enrollment *(40)*. Although improvement was seen in both groups, greater improvements in mean pain and functionality scores were reported in patients who underwent IDET. Pauza and colleagues' use of provocative discography rather than MRI

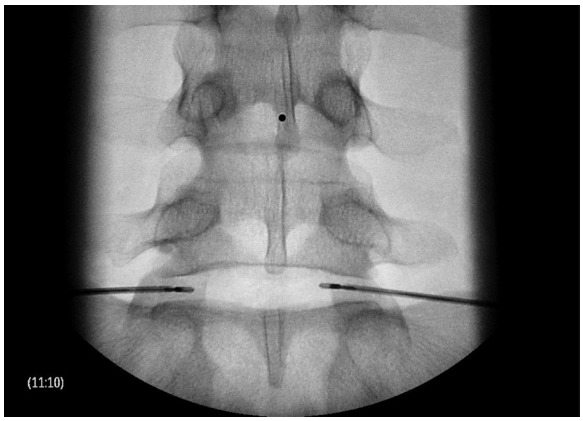

Figure 3. *Anterior-posterior view of the intradiscal biacuplasty electrodes within the annulus of L5–S1 intervertebral disc. Notice the appropriate distance of the active tip of both electrodes from the end-plates and limited depth of the radiofrequency active tip (distal to radiopaque marker) just up to medial pedicle border.*

criteria for enrollment may have contributed to the negligible improvements seen in the IDET patients, as well as the high number needed to treat – five to achieve >75% improvement in one patient *(40)*. There was significantly less improvement in functional capacity and pain relief following IDET in a separate prospective study in which patients with any sign of disk degeneration on MRI at more than two lumbar levels were compared with patients who had one or two degenerated disks. In this particular study, patients were matched for the number of lumbar disk levels positive on discography *(46)*. As single-level disease is less commonly present, it is reasonable to believe that Pauza and colleagues' patient selection realistically illustrates the expected results of the IDET procedure in the majority of patients presenting with discogenic pain *(40, 46)*. Overweight patients *(47)* and patients receiving workers' compensation benefits *(45, 48)* represent additional patient subsets that are unlikely to benefit from IDET.

Using significantly different selection criteria than Pauza et.al, the recently published randomized, double-blinded, controlled IDET study by Freeman and colleagues reported no significant improvement between treatment and placebo in patients with discogenic pain *(49)*. Importantly, selection criteria for this study did not include data regarding body mass index, depression scores, nor the number of disk levels that appeared degenerated on MRI. Further, more that half of the enrolled patients exhibited »marked functional disability« and were receiving workers compensation benefits at the time of their participation in the study. Freeman and colleagues also used patients belonging to groups previously referred as likely IDET failures *(45, 48, 49)*.

IDET is not the only minimally invasive annuloplasty procedure. However, no differences in pain scores or improvement in functional capacity between the sham and the treated patient groups were seen in the randomized controlled trial using the original Sluijter radiofrequency (RF) technique in which the nucleus was heated to 700C for 90 seconds *(50)*. A disappointing performance was turned in by the novel annular probe termed »DiscTrode« as well, after treatment of patients with discogenic pain reported only modest improvements in pain scores and functional capacity *(51)*. This technology proved to be less effective in improving functional capacity and VAS scores versus IDET when strict patient selection criteria were employed *(51)*.

Transdiscal biacuplasty is the latest minimally invasive posterior annulus heating technique. This technology employs bipolar RF electrodes and – based on improvement in pain scores and functional capacity in patients with discogenic pain – is likely the most promising of all currently available minimally invasive, disk-heating methods *(51-55)*. This method works specifically by concentrating RF current between the ends of two straight probes. Deep, even heating over the larger area of the posterior annulus is achieved by internally cooling the electrodes *(52)* (Figure 3). Disks with large radial fissures, and at levels where placement of the IDET resistive coil may be technically difficult, (i.e. L5-S1), represent additional indications for transdiscal biacuplasty *(55)*.

Contained Disk Herniation–Minimally invasive decompression

A common cause of leg and back pain is the contained protrusion of the lumbar intervertebral disk. When contained, smaller protrusions are less likely than larger disk extrusions to spontaneously resorb *(56)* and often show less improvement from surgical discectomy *(57)*. In an effort to speed functional recovery, yet provide similar efficacy as open surgical procedures, percutaneous discectomy and disk decompression have become attractive therapeutic alternatives for such lesions. One percutaneous method of central decompression, in particular, attempts to avoid extensive damage to the annulus by simply removing or degrading a portion of the nucleus pulposus at the center of the disc without removal of the actual herniated disk material *(58, 59)*. Although there are no clinical comparison studies or individual prospective controlled studies to confirm the data, reported success rates for these types of procedures ranges from 55% to 90% *(58)*. The percutaneous techniques are also hoped to produce less pain following surgery, less nerve root scarring at the site of intervention, lower incidence of spinal instability and/or disc space collapse, less cost and a faster return to full function.

The three most recent techniques developed for the minimally invasive treatment of contained herniation of the nucleus pulposus are: Coblation technology (RF nuclear tissue vaporization) nucleoplasty; heated resistive coil catheter disk decompression; and a volume reduction/intradiscal decompression technique known as Dekompressor (Stryker).

Improvements in both functional capacity and pain relief were seen with nucleoplasty secondary to its ability to ablate and coagulate the nucleus pulposus, thereby de-

compressing the disk and thermally altering the disk tissue *(60–62)*. A case series of 65 patients claimed a success rate of 80% and VAS pain score reduction from 7.7 to 3.3 at 1-year follow-up *(60)*. VAS pain scores were reduced by 71% at 3 months and 59% at one year in another case series *(61)*. Importantly, decompression is more effective in non-degenerated disks than in previously degenerated ones *(62)*. In addition to this consideration, accepted indications include: radicular pain greater than axial pain for more than 6 months as well as failure of physical therapy and conservative treatments. Less favorable outcomes are seen in the setting of large disk protrusions, less than 50% of disk height maintained, and those with significant prolapse above and below the disk level, thus warranting careful review of all patients' MRI images. A patient with a contained disk protrusion of <6mm whose annular integrity is documented by discography and who has consistent radicular symptoms confirmed by selective nerve root blocks represents the ideal candidate for annuloplasty or any percutaneous decompression *(58, 63)*. Some patients who have had either unsuccessful selective nerve root blocks or had simultaneous axial and radicular pain may require provocative discography but, in general, selective nerve root block is adequate to verify that the pain is originating from the selected disk.

Disk space infection, complete disk collapse preventing access to the intervertebral space, and comorbid conditions precluding the safe performance of the procedure represent contraindications to nucleoplasty. These procedures are also generally not of significant benefit in patients with scoliosis, progressive neurological deficits, significant canal stenosis, tumors, or with prior surgeries at the same intervertebral level *(64)*.

The second technique, the percutaneous decompression (Dekompressor) technology, extracts nuclear disk material by an auger within a cannula that ends inside the nucleus. A significant change in intradiscal pressure follows the reduction of nuclear volume within the closed hydraulic space. It is imperative that the annular wall be intact for this technique in order to retract the bulging section, therefore provocative discography may occasionally be needed to confirm the affected level and to rule out any annular disruption. In their case series, Alo and colleagues reported an 80% success rate with this technique *(59)*.

The Decompression catheter (Smith and Nephew, London, UK) is a recently introduced electrothermal intervertebral disk decompression technique that utilizes thermal energy for focal decompression of contained herniated disks. In this technique, a 1.5cm resistive coil capable of developing localized heat in a section of the catheter is carefully positioned over the contained protrusion. This resistive coil is capable of significant heat production, and should therefore not be used in patients with <50% disk height. In appropriate patients, the technology may be an effective approach to the treatment of patients who have both axial and radicular pain, but currently there exist no case series or in-depth clinical studies yet published to support this hypothesis.

CONCLUSIONS

Several new minimally invasive disk and vertebral repair techniques for pain control have been introduced recently, but sufficient clinical evidence of their efficacy and extent of application is still lacking overall. One thing that is clear, however, is that careful patient selection based on the present data significantly improves the success of these procedures.

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